# MM 24: Topical session: Caloric Effects in ferroic materials II - Methods and Applications

Time: Tuesday 11:45–13:15 Location: H53

**15 min. coffee break**

MM 24.1 Tue 12:00 H53

**Detailed loss analysis of a magnetocaloric demonstrator using FEM-simulations** — •Dimitri Benke, Tino Gottschall, Fabian Jäger, Marc Pabst, Konstantin Skokov, Iliya Radulov, and Oliver Gutfleisch — TU Darmstadt, Institute of Material Science, Alarich-Weiss-Str. 16, 64287 Darmstadt, Germany

The performance of many magnetocaloric materials has been reported and compared many times in the literature [1-3]. However, this comparison is mostly not done in conditions mirroring the real device. In order to assess materials in an environment being comparable to application, a magnetocaloric test bench was built. This demonstrator can be used to compare the performance of a material under cyclic conditions being in contact with an oscillating heat exchange fluid.

In order to assess the suitability of a material, the different loss mechanisms during operation of the demonstrator have to be evaluated. By this it is possible to make full use of the potential of the materials. This has been done by combining measurements of the temperature span and FEM simulations of the magnetocaloric test bench when varying the system parameters.

This work was supported by the Darmstadt Graduate School of Excellence Energy Science and Engineering.

[1] M.E. Wood, W.H. Potter, Cryogenics Vol. 25, Issue 12,(1985)665.
[2] K.G. Sandeman, Scripta Mater. 67 (2012) 566.
[3] D.D. Belyea et al. ,Sci. Rep. 5 (2015) 15755.

MM 24.2 Tue 12:15 H53

**In-situ XRD and 3D imaging techniques for the study of magnetocaloric materials** — •Anja Waske[1,2], Alexander Funk[1,2], Kai Sellschopp[1,2], Alexander Rack[3], and Sebastian Fähler[1,2] — [1]IFW Dresden, Helmholtzstraße 20, 01069 Dresden, Germany — [2]Institute for Materials Science, TU Dresden, Helmholtzstraße 7, 01069 Dresden, Germany — [3]ID 19, ESRF, 6 rue Jules Horowitz, 38043 Grenoble Cedex, France

In magnetocaloric La(Fe,Si)13, an isostructural first-order transition connected with a volume change of around 1.5 vol.% occurs at the critical temperature Tt. We use in-situ computed tomography and situ X-ray diffraction to study this magnetovolume transition as a function of temperature. The experiments have been carried out at the beamline ID 19 at the ESRF in Grenoble (tomography) and the Petra III /2.1 beamline at DESY in Hamburg, respectively. We show that i) by 3D imaging it is possible to track the magnetovolume transition, ii) nucleation and growth of the ferromagnetic phase depends strongly on surface morphology and iii) the virgin effect in magnetocaloric La(Fe,Si)13 is connected to the formation of cracks [1]. These findings connect microstructural aspects of the first-order transition to important properties like hysteresis and kinetics of the phase transition and can therefore help to tailor magnetocaloric materials towards application. Funded by DFG through SPP 1599 www.FerroicCooling.de.
[1] A. Waske et al., PSS-RRL 9 (2) 136-140 (2015)

MM 24.3 Tue 12:30 H53

**Direct vs indirect Monte-Carlo methods for calculating the electrocaloric effect** — •Constanze Kalcher, Alexander Stukowski, and Karsten Albe — FG Materialmodellierung, FB Materialwissenschaft, Technische Universität Darmstadt, Germany

Conventionally, the electrocaloric effect is determined indirectly by integrating Maxwell's relation. However, a number of approximations are usually made during the process, such as assuming a constant heat capacity. In this contribution we want use a computer model to show to what extent these approximations affect the resulting adiabatic temperature change and how to eliminate possible error sources. Therefore we present three Monte-Carlo methods: (a) Metropolis, (b) Wang-Landau and (c) Creutz, that allow to calculate the adiabatic temperature change of the electrocaloric effect on a 2 dimensional 4-state Ising model. We show that both the direct and indirect approach lead to the same result, but for the indirect route great care has to be taken when performing the numerical integration over the pyroelectric coefficients and the entropy.

MM 24.4 Tue 12:45 H53

**In-situ synchrotron XRD investigation of the structural phase transition in epitaxial Ni-Mn-Ga-Co thin films on ferroelectric substrates** — •Benjamin Schleicher[1,2], Stefan Schwabe[1], Robert Niemann[1,2], Anett Diestel[1], Anja Waske[1], Ruben Hühne[1], Peter Walter[3,4], Ludwig Schultz[1,2], Kornelius Nielsch[1], and Sebastian Fähler[1,2] — [1]IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany — [2]TU Dresden, Institute for Solid State Physics, D-01062 Dresden, Germany — [3]Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, D-22607 Hamburg, Germany — [4]2$^{nd}$ Institute of Physics B and JARA-FIT, RWTH Aachen University, D-52047 Aachen, Germany

For solid-state refrigeration, the phase transition in Ni-Mn-Ga-Co can not only be influenced by magnetic fields, but also by mechanical stress. This can be achieved by straining an epitaxial magnetocaloric thin film via a ferroelectric substrate. We investigated sputter deposited epitaxial Ni-Mn-Ga-Co thin films on ferroelectric $Pb(Mg_{1/3}Nb_{2/3})_{0.72}Ti_{0.28}O_3$ (PMN-PT) substrates. Temperature dependent texture and magnetic measurements show the structural and magnetic phase transition in the material. In-situ synchrotron XRD measurements on the P02.1 beamline at PETRA III (DESY, Hamburg) have been used to demonstrate the influence of mechanical stress on the phase transition by in-situ application of an electric voltage to the multiferroic stack and a temperature-strain phase diagram was obtained. Funded by DFG through SPP 1599 www.FerroicCooling.de.

MM 24.5 Tue 13:00 H53

**Magnetocaloric properties of freestanding and substrate-constrained Ni-Mn-Ga-Co films** — •Anett Diestel[1,2], Robert Niemann[1], Benjamin Schleicher[1], Stefan Schwabe[1,2], Ludwig Schultz[1,2], and Sebastian Fähler[1] — [1]IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, D-01171 Dresden, Germany — [2]TU Dresden, Institute of Materials Science, D-01062 Dresden, Germany

Ferroic cooling processes that rely on field-induced first-order transformations of solid materials are a promising step towards a more energy-efficient refrigeration technology. In particular thin films are discussed for their fast heat transfer and possible applications in microsystems. They can be used as model systems to understand the transformation mechanism. We analyze the martensitic transformation in substrate-constrained and freestanding epitaxial Ni-Mn-Ga-Co films. By means of M(T) and M(H) measurements in vicinity of the phase transformation, we compare entropy changes and field-temperature phase diagrams, which differ only slightly depending on the scanning parameter. These effects are related to the vector character of a magnetic field, which acts differently on the nucleation and growth processes compared to the scalar character of temperature. We observed an asymmetric thermal hysteresis between the ferromagnetic austenite and the ferromagnetic martensite. The sharp cooling but gradual heating branch at low magnetic fields is explained by using a microstructural model of martensitic transformation describing energy barriers of nucleation and growth processes. This work was funded by the DFG SPP1599.